AIR CARGO OPERATIONS MANAGEMENT AND CAPACITY DEVELOPMENT POTENTIAL IN INDIA

SYNOPSIS

SUBMITTED IN THE PARTIAL FULFILLMENT FOR THE REQUIREMENT OF

DOCTOR OF PHILOSOPHY

IN

MANAGEMENT

Submitted by

NANCY KATIYAR

Under The Supervision of

PROF. SANJAY BHUSHAN

Co-Supervisor
Department of Management
Faculty of Social Sciences

DR. ARVIND KUMAR

Supervisor
Department of Management
Faculty of Social Sciences

DEPARTMENT OF MANAGEMENT, FACULTY OF SOCIAL SCIENCES

DAYALBAGH EDUCATIONAL INSTITUTE (DEEMED TO BE UNIVERSITY)

DAYALBAGH, AGRA – 282005

2023

CONTENTS

SECTION 1:

Introduction……1

1.1 Introduction To Air Cargo Operations Management…….…....1

1.2 Emergence Of Global Trade Demand……...…….....….....1

1.3 Capacity Development Potential……...……....……2

1.4 Conceptual Framework……...…….....3

1.5 Introduction To Indira Gandhi International Airport (IGIA), New Delhi.....4

1.6 Introduction To Chhatrapati Shivaji Maharaj International Airport (CSMIA), Mumbai…….5

1.7 Significance of the Study…….……...….....7

SECTION 2:

Literature Review…….……...…….....9

SECTION3:

Objectives of the Study……..……..……..…..……..19

SECTION 4:

Research Design and Methodology……....…...……20

4.1 Formulation of Hypothesis…….…….…....20

4.2 Pilot Study……...……...…...…21

4.3 Sample Composition…….....….21

4.4 Sampling Technique……...…..22

4.5 Modelling and Simulation Tools for Analysis……...23

4.6 Methodology…….……..…...…24

4.7 Plan of Work.....25

SECTION 5:

Proposed Chapterization of Thesis…….…….....27

Chapter I: Introduction

Chapter II: Review of Literature

Chapter III: Research Design and Methodology

Chapter IV: Analysis and Results

Chapter V: Conclusions

Appendix

References

SECTION 1: Introduction

1.1 Introduction to Air Cargo Operations Management

Air cargo provides the benefits of speed, reliability, security, and reduction of inventory cost. The existence of a well-developed air cargo infrastructure benefits not only the airport, but a region's economy as well as the Airports with high cargo volume attracting major industries towards itself acting like magnets.

According to IATA, Airlines transport over 52 million metric tons of goods a year, representing more than 35% of global trade by value but less than 1% of world trade by volume. That is equivalent to $6.8 trillion worth of goods annually, or $18.6 billion worth of goods every day.

Air freight/cargo can be defined as all cargo moved by air except for mail and passenger baggage. Air cargo transport is achieved either through dedicated freighters or by belly capacity in passenger aircraft.

The Air cargo operations is the process of receiving, storing, transferring, tracking, loading and unloading of cargo. This process involves following players:

- Shipper (or Consignor) - The one who requests service in transporting the cargo (source node of the supply chain)
- Freight forwarder (or forwarder) - The one who arranges for the transportation of cargo from the shipper's warehouse, delivers it to the departing airport, prepares the necessary paperwork, picks up at the arriving airport, and delivers to the consignee.
- Carrier - The firm who provides the air delivery of cargo from the origin airport to the destination airport.
- Ground Handler - An agent at an airport that physically handles the freight; this usually refers to whenever freight is loaded, unloaded, transferred, stored, retrieved, broken down, or consolidated.
- Consignee - The receiving party that the goods are sent to (sink node of the supply chain).

1.2 Emergence of Global Trade Demand

Global trade and the GDP have grown tremendously in the past decades, primarily due to contribution of emerging market economies in international trade. The best example of this is the increasing market share of Asian countries in global trade in the recent years. India is one of the emerging economies that

has targeted to have a significant share in global trade.

Global trade has also been enhanced due to liberalization of transportation and other regulations in addition to open skies, airline alliances and relaxed airline ownership rules. Advancement in technologies also facilitate and improve global trade. For example, the introduction of universal barcode has increased the movement and flow of goods worldwide. The importance of air cargo technology which provide fast and safe transportation in global trade is increasing day by day due to prominence of the time factor.

Air freight is required for time-sensitive (high-value) commodities such as documents, pharmaceuticals, fashion garments, production samples, electronics consumer goods which have a short marketing life and perishable agricultural and seafood products because it offers speed, security and reliability. Air freighters enable the most economical sourcing of components and assemblies. The trend of increasing number of global manufacturing hubs has led to growth in the use of just-in-time (JIT), where particular parts must arrive for assembly at specific times resulting manufacturers depend on air freight services for efficient just-in-time inventory management and to ensure their availability for final assembly.

1.3 Capacity Development Potential

The capacity of airports to handle cargo traffic is determined by the rate at which cargoes are processed for transshipment. In general, capacity refers to the ability of an airport to handle a given volume and types of cargo demand without operational penalty. Airport capacity for cargo handling can be said to be constrained when the infrastructure and facilities provided at the terminals are not able to perform effectively so as to handle the demanded tonnage of cargo efficiently. Airport capacity constrain is expressed as the inability of an airport to handle the maximum number of units of demand that can be accommodated during a given period of time and under given conditions. Airports which are capacity constrained in one or the other way will have difficulty in accommodating new airlines or expanded services by the incumbent carriers.

1.3.1 Air Cargo Demand Forecasting

The volume of air commodity production, consumption and/or distribution within that airport's catchment area primarily determine the cargo demand for an airport. The location and competitiveness of alternative airports or modes of transport also affect the cargo demand for any particular airport.

The airport capacity and the demand for service by aircraft operators form the major features in the measurement of traffic growth of any airport. These features influence the volume and types of cargoes that an airport can attract. Ensuring adequacy of capacity and handling the anticipated demand of traffic in an efficient manner is the prime focus of airport management.

The demand forecasts should not take facility constraints or other outside limiting factors into consideration. In other words, for purposes of estimating future demand, forecasts should assume that adequate facilities can be provided to meeting the demand. After determining what facilities are needed to accommodate the forecast aviation activity, alternatives can be identified and evaluated in order to provide any physical improvements.

1.4 Conceptual Framework

The Figure 1 represents the linkages between the Air Cargo Operations, Capacity Planning and Air Cargo demand forecasting which forms the basis of conceptual framework for the proposed research work. Various operations within the air cargo chain and the assessment of capacity infrastructure have been obtained from the literature review. Furthermore, according to analysis done by Suryani et al. it has been found that air cargo demand has been increasing worldwide and there is a need to forecast air cargo demand related to terminal capacity expansion. In this study, the researcher proposes to map the relationship between Air Cargo Operations, Capacity Planning and Air Cargo Demand Forecasting. This study will benefit the Airport Authorities and other stakeholders in determining terminal capacity planning in accordance with the availability of Air Cargo tonnage.

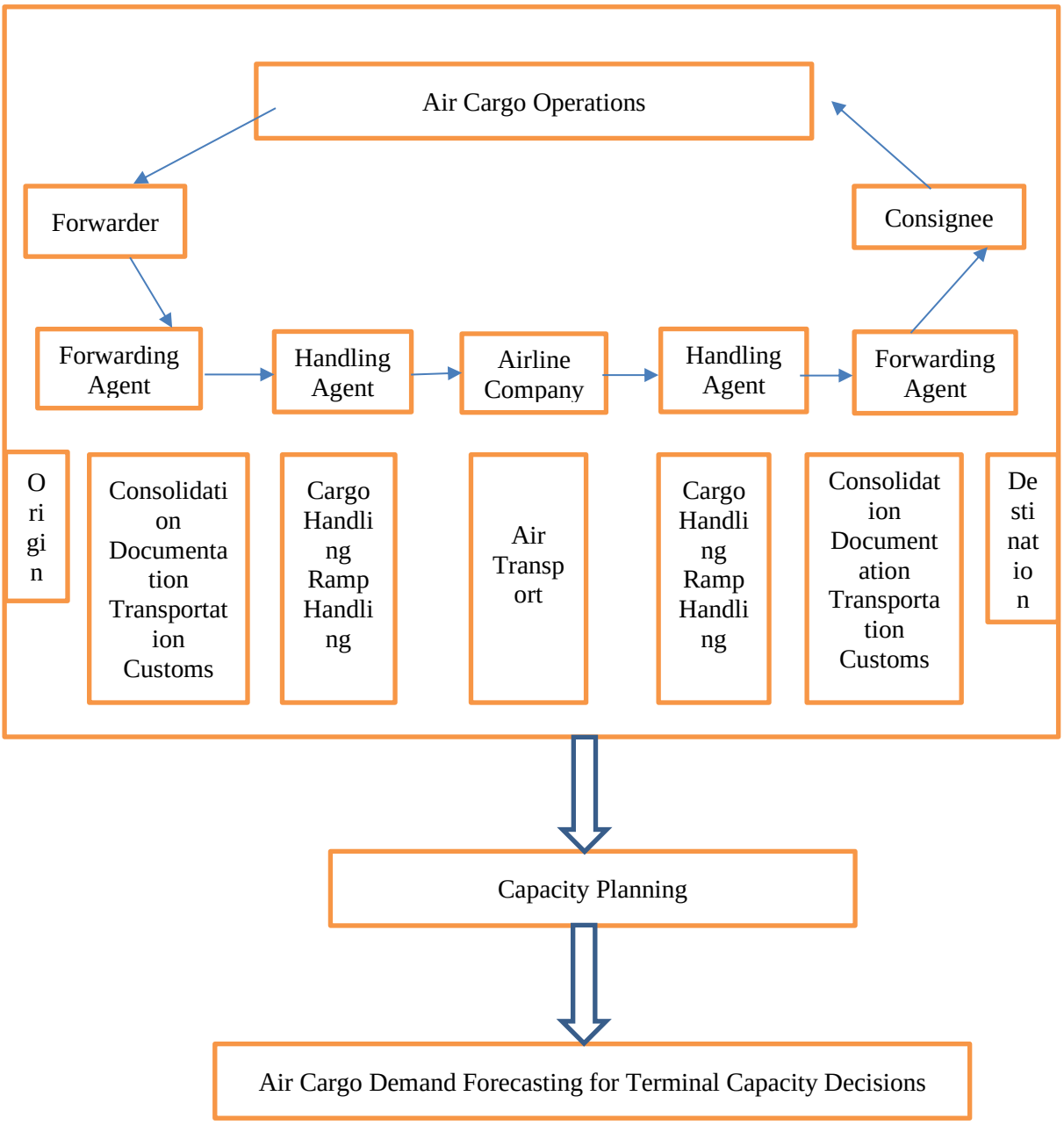

Figure 1: Conceptual Framework
(Source: Author's own compilation)

1.5 Introduction To Indira Gandhi International Airport (IGIA), New Delhi

Nowadays, many countries invest in logistics sector to take advantage of the enormous potential of this sector. India also has an important position in the world in terms of the logistics sector as it is advantageously positioned from a geographic point of view, situated between the manufacturing hubs to the east and south east of Asia, and with the consumption centers in Europe and the Americas. Indira Gandhi International (IGI) Airport in New Delhi, having 27th rank in the World Cargo Traffic Rankings

(2021) has the highest cargo volume in India which is suitable for such a development scenario.

Indira Gandhi International Airport (IGIA), located in the capital of the Country at New Delhi, is the preferred Air Cargo Hub of India not only because of its strategic location, but also as it has an elaborate state-of-the-art infrastructure spread over an area of 150 Acres and efficient air cargo handling services with 2 Integrated cargo terminals (CDCTMIPL and DCSC) and on-airport logistics center. Two specialized Cargo Terminal Operators namely Celebi Delhi Cargo Terminal Management India Pvt. Ltd. (CDCTMIPL) and Delhi Cargo Service Centre (DCSC) were appointed in 2009-10 as concessionaires for operating and managing the cargo handling activities at the Airport.

CDCTMIPL has upgraded and modernized the existing cargo terminals while DCSC has developed a greenfield terminal with modern facilities bringing the overall capacity of cargo terminals to 1.8 million Metric Tonnes per annum scalable to 2.5 million Metric Tonnes per annum. The IGIA has largest airline network connecting 75 International and 69 Domestic destinations served by 63 Air carriers and 17 Freighter airlines making it India's largest Air Cargo gateway handling over One Million Metric Tonnes of cargo annually ("The Leading Air Cargo Hub of India." Delhi Airport Cargo | South Asia's Largest Cargo Gateway).

Being started in 2006, Delhi Airport Cargo has grown significantly witnessing a sustained business growth with a CAGR of 7-8% in the last one decade. With over 28,000 sqm of on-airport logistics facilities within the airport premises, it offers a great benefit to the freight forwarders & logistics companies in fulfilling their need of consolidation & value add activities thus improving the efficiency of air cargo supply chain.

Delhi Airport, an Air Cargo Gateway of South Asia, has a large infrastructure to support efficient handling of domestic as well as international cargo, contributing 29% volume of India's total air cargo handling capacity. IGI Airport is continuously implementing new initiatives to benefit all the stakeholders involved in the air cargo supply chain by enhancing the operational efficiencies and boosting cargo growth.

1.6 Introduction to Chatrapati Shivaji Maharaj International Airport, (CSMIA)

Located in the financial capital of India, Chhatrapati Shivaji Maharaj International Airport (CSMIA) in Mumbai stands as a testament to the city's bustling trade and commerce activities. The airport, one of

the busiest in the country, plays a pivotal role in handling a significant portion of the nation's air cargo. The airport is operated by Mumbai International Airport Limited (MIAL), a Joint Venture between the Airports Authority of India and the GVK Industries Ltd led consortium which was appointed in February 2006 to carry out the modernization of the Airport. The new integrated terminal T2 was inaugurated on 10 January 2014 and opened for international operations on 12 February 2014. It is the second busiest airport in the country in terms of total and international cargo traffic after IGIA New Delhi, and was the 14th busiest airport in Asia and 41st busiest airport in the world by passenger traffic in fiscal year 2019. In February 2021, the Adani Group acquired both GVK and Bidvest's stakes in MIAL, giving it a controlling interest of 74% in the venture.

Given Mumbai's stature as a primary trade and financial hub, CSMIA serves as a vital gateway for imports and exports. The airport's location offers excellent connectivity to major ports, industrial zones, and commercial centers of Western India. Handling millions of tonnes of cargo annually, CSMIA continually witnesses growth in cargo operations. The airport's cargo volume stands as a testament to Mumbai's position in global and domestic trade.

In conclusion, Chhatrapati Shivaji Maharaj International Airport, Mumbai, is more than just a transportation hub; it's a linchpin in India's trade network. CSIMA in Mumbai, having 30th rank in the World Cargo Traffic Rankings (2022) has the second highest cargo volume in India which is suitable for such a development scenario. By ensuring the efficient, secure, and swift movement of goods, CSMIA contributes significantly to the nation's economic growth and global trade connectivity.

Here's a list of the primary air cargo terminals at CSMIA:

1. **Sahar Air Cargo Complex**: This is the main air cargo complex located in the Sahar neighbourhood, which traditionally handled the majority of the international cargo operations.
2. **Mumbai Cargo Terminal I**: This terminal caters predominantly to domestic cargo.
3. **MIAL Cargo Terminal**: Mumbai International Airport Limited (MIAL) manages this terminal which handles a mix of both domestic and international cargo.

The total freight tonnage handled at Indian airports in financial year 2022 was at 3.14 million metric tons. The majority of this was international freight. Three major airports, namely Indira Gandhi International Airport in Delhi, Chhatrapati Shivaji International Airport in Mumbai, and Kempe Gowda

International Airport in Bengaluru, handled nearly half of the air freight of the country.

However, some problems identified in cargo operations in India are as follows:

- Lack of planned and integrated development of airports to cater to the needs of cargo business
- Lack of adequate and appropriate air-cargo infrastructure at airports remains the key stumbling block to the future growth of the air cargo sector in India.
- Shortage of landside truck docks vehicle holding area and airside operational space
- Insufficient entry gates and lack of upgraded handling equipment and trolleys
- Lack of specialized storage & handling facilities for hazardous, radioactive & valuable cargo
- Lack of sufficient cold storage capacity for perishables cargo

Furthermore, there exist some glaring infrastructure gaps of cargo operations in India, when compared with global best practices as shown in the Table 1:

Table 1: Gaps of Cargo Operations

Global best practices	**Cargo operations in India**
Segregated facilities for different types of cargo	Most terminals don't offer separate facilities, except cold rooms
Dedicated and specialized perishable handling facilities that cater to end-to-end supply chain needs	Inadequate investments in cold chain infrastructure (temp-controlled warehouses, trucks) to handle agricultural, pharma and other perishable commodities
Proper waiting area for trucks	Agents use the cargo terminal landside as a truck parking / holding area, leading to congestion
Agent warehouses, office spaces and other processing facilities close to cargo terminal	Agent warehouse are often located within the city
Promotes transshipment handling/ hub operations	Cargo terminal operators need to have separate license handling area for transshipment handling
Dedicated facilities for Air Express Operations with air side and city side access, multiple freighter parking bays	No fixed model and dependent on decision of individual airport operators. Very few dedicated freighter parking bays.

(Source: Ministry of Civil Aviation Report)

Given those features, the researcher proposes to assess the air cargo potential of IGIA, New Delhi and CSMIA, Mumbai and to finally develop a model which will evaluate different scenarios related to decision making for air cargo terminal capacity expansion planning.

1.7 Significance of the Study

According to IATA, air cargo transports over US $6 trillion worth of goods, accounting for approximately 35% of world trade by value which means that air cargo business is high in value and

low in volume.

The overall capacity of any airport to handle cargo efficiently is determined by processing of cargo without delay and at reduced cost which is attributed to the quantity and condition of the infrastructure facilities at the Airport. The delay in cargo traffic at airports results into high cost and increased transshipment time.

Due to demand uncertainties, terminal capacity management has been a challenge for the airport authorities. Therefore, there is a need to develop a model to support the long-term capacity management. Cargo forecasts are important to airports for many reasons including master planning and budgeting. Airports that accurately forecast their future traffic will better anticipate the needs of their customers, and thus will be in a better position to develop to their full potential.

As per above, this study will assess the capacity of IGI airport in the handling of cargo traffic in terms of the adequacy and condition of warehouse, handling equipment, processing shed, and storage facilities. Also explained in the Figure 2, as Air Cargo Demand is increasing day-by-day due to Global Trade Activities, an assessment of the Cargo Terminal Capacity becomes imperative, for which demand forecasting is required. Based on the forecasted demand, adequacy of the capacity can be calculated. In addition to this, terminal capacity expansion can be planned based on the different scenarios projected.

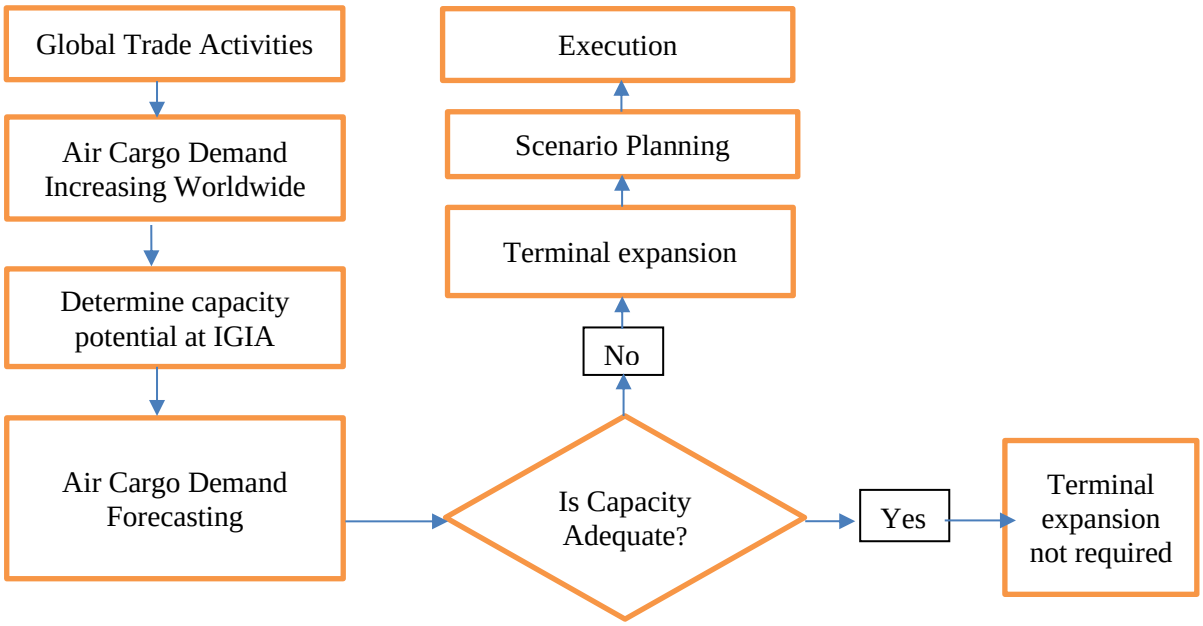

Figure 2: Terminal Capacity Planning
(Source: Author's own compilation)

SECTION 2: Literature Review

A brief summary of the literature review is described in the following Table 2:

Table 2: Literature Review

Air cargo Operations and Capacity utilization			
S.no.	**Name of Author/ Report/ Book**	**Year**	**Major variables/ dimensions studied**
1.	P.S. Senguttuvan	2006	Describes concepts and theoretical aspects of 'airport capacity'
2.	Anderson R. Correia	2007	Derives quantitative relationships between physical measures and passenger responses
3.	Kannapha Amaruchkull	2010	Study of allotment management to the case of multiple forwarders
4.	Volodymyr Bilotkach	2011	A bridge between the theoretical insights and their practical application to airports, the airport market power assessment exercises
5.	Marc C. Gelhausen	2011	Analyses the effect of limited capacity on air traveler's airport choice
6.	Vikrant Vaze	2012	Assessment of the impact of demand management strategies for efficient allocation of airport capacity using revenue management
7.	MoCA Report	2012	Infrastructure gaps of cargo operations in India, when compared with global best practices
8.	Yibin Xiao	2015	Effects of airport-airline cooperation on airport capacity choices by developing a multistage model
9.	ICAO Report	2015	It is designed for awareness of the air cargo and mail supply chain also contains new material on the economic impact of cargo movements, recognizing how international distribution chains can be an engine for regional economic development.
10.	Yibin Xiao	2016	Model analyzes airports' capacity investment, pricing decision, airline competition and alternative airport objectives
11.	Allan Nommik	2017	Findings of this research should be implemented as the input for the regional airport terminal modelling
12.	P.M. Picard	2019	Impact of capacity constraints on one of the main factors underlying the use of time slots.
13.	AJ Adenigbo	2019	To develop the relationship between the concepts of air cargo operations and terminal capacity planning.
14.	ACI Report	2019	This guide is an ideal instrument to expand the knowledge base of air cargo.
15.	Siddhartha Ghosh	2022	It is expected that the operations of warehouse can be structured effectively and also type of cargos.
16.	Anne Graham	2023	Availability of data airport cargo tonnes by world region 2019-2021.
17.	Joachim G. Schäfer	2023	Here the explanations dealt with who is directly and indirectly involved in the handling of an air freight shipment.
18.	Rosalin Sahoo	2023	The valuable and critical managerial insights gained from this study would be instrumental to the several officials of the AAI, freight forwarders, airline service providers, and stakeholders involved in the air cargo supply chain

Air cargo Demand-Forecasting and Capacity Expansion			
19.	Robert L. Eberlin	1985	Understanding of statistical and system dynamic tools.
20.	Yaman Barlas	1996	Emphasis on the crucial nature of structure validity in system dynamics
21.	James M. Lyneis	1998	Model was used to identify structural changes in aircraft industry, to avoid unnecessary capacity expansion, and to identify strategies to best "bridge" a business downturn.
22.	John D. Sterman	2000	This book is designed to provide thorough coverage of the field of system dynamics.
23.	James M. Lyneis	2000	He claims that the structural orientation of system dynamics models provides more accurate depictions of short and mid-term behaviour than statistical models, which often become skewed by noise in the system
24.	Hong Jiang	2003	Forecast was made on the relationship between air cargo traffic and economic development. There is a relationship between GDP and air cargo demand
25.	Cheng-Chang Lin	2003	Analysis of government documents and interview of the air cargo carriers and airlines
26.	Jack E. Houston	2004	First study of broiler water demand forecasting by incorporating economic variables
27.	Matthew G. Karlaftis	2008	Forecasting highly seasonal demand in regional airports, where peak flows approach airport capacity
28.	Wen-Yi Peng	2009	Search for a model that can provide the most accurate prediction of container throughput by using six univariate models
29.	Erma Suryani	2010	A model to forecast air passenger demand and passenger terminal capacity expansion
30.	Erik Pruyt	2011	Two model-based approaches for supporting policymaking for complex and uncertain issues
31.	MoCA Report	2012	There exist gaps in the facility infrastructure at Cargo terminals in Gateway airports.
32.	Erma Suryani	2012	Analysis of the relationship between the concept's: terminal capacity planning and air cargo demand forecasting.
33.	Uriel Magaña Olmos	2016	To explore and untangle the factors influencing demand forecasting and consequently to improve the operational performance of an Air Cargo Handling Company
34.	Alexandre Jacquillat	2017	Major interventions available to manage airport demand and capacity, the analytical tools that may support the underlying policy, managerial and operational decisions and guidelines for policy.
35.	Boeing Forecast Report	2022	Global economic indicators that impact air cargo and a variety of analytical methods for forecast are discussed.
Global Trade			
36.	Michael E. Porter	1990	Correlation between air cargo and GDP growth. Also, FDI can generate competitive strength to nation's economy.
37.	Anming Zhang	2002	The air cargo volume throughout of the world has strongly linked to trade growth and has grown at between 1.5 and 2 times the rate of worldwide GDP growth

38.	Hiroshi Ohashi	2004	Critical factors influencing air cargo transshipment route choice decisions and analysis focuses on the trade-off between monetary cost and time cost
39.	John D. Kasarda	2005	There exists an empirical relationship between air cargo and trade and gross domestic product per capita
40.	Xiaoying Li	2005	Foreign direct investment (FDI) affects economic growth
41.	Jim Love	2005	GDP, trade and exports have co-integration.
42.	Shujie Yao	2006	FDI and export have a relationship.
43.	P.S.Senguttuvan	2006	Air cargo, trade, and GDP have a direct relationship and are interdependent
44.	Frank S.T. Hsiao	2006	Causality relations between GDP, exports, and FDI
45.	Hidenobu Matsumoto	2007	Cities are strengthening their position as international air transportation hubs
46.	IATA Report	2021	In 2020, air cargo generated $128 billion, which, at 34%, represented approximately a third of airlines' overall revenues, an increase of 10-15% compared with precrisis times.
47.	IATA Report	2022	Air cargo generated $155.0 billion in 2021, up from $129.0 billion in 2020.
48.	Boeing Forecast Report	2022	Air cargo accounts for less than 1% of the world's trade tonnage, the high value of these goods means it is responsible for about 35% of the value of all globally shipped goods.
49.	IBEF Report	2022	Growth in import and export in India will be the key driver for growth in freight traffic as 30% of total trade is undertaken via airways.
50.	M.S. Bhonsale	2023	Air connectivity boosts economic growth thus enabling trade through investments.
51.	Sachin Gupta	2023	Theoretical Frameworks for FDI Determination

(Source: Authors own compilation)

2.1 Air cargo Operations and Capacity utilization

Capacity of air cargo can be managed by strategically handling air cargo across the origins and destinations (Sahoo et. al., 2023). Previous research done by (Senguttuvan, 2006) has described the concept and theoretical aspects of 'airport capacity' on airside and landside and also it explodes the case study of major airports of US, Europe and Asia Pacific. It also briefly describes the short-term and long-term planning of airport capacity. Further, the study also briefly reveals the measures to alleviate airport congestion and delays through short term plan and long-term plan and congestion charging mechanism for peaks and off-peaks with the help of Marginal and Average cost pricing structure. In addition to this, a study conducted by (Ghosh, 2022) analyzed that the operations of warehouse can be structured effectively, improvement in the work efficiency can be achieved by avoiding the offloading and by optimizing the manpower utilization with highest possible productivity. (Gelhausen, 2011) analysed the

effects of limited capacity on air travellers' airport choice. The analysis was based on a market-segment specific airport choice model that accounts for limited capacities and also scenarios relating to the capacity situation at airports. The study reveals the mutual dependence among airports. Capacity constraints at one airport cause spill-over effects and thus influence air travel demand served at other airports. In some cases, this may even lead to new capacity constraints. (Xiao et.al., 2016) determined the effects of airport-airline cooperation on airport capacity choices by developing a multistage model, in which competing airlines contribute to capacity investments, and share airport revenue proportional to their respective capital commitments. The model simultaneously considers airport-airline vertical arrangements, airline competition, and airport capacity choice in the presence of demand uncertainty. In addition to this, (Xiao et.al., 2016) analyzed optimal choice of the airport capacity to invest immediately (the prior capacity) and the size of real option to acquire for possible future expansion. The model analyzes airports' capacity investment, which has large sunk-costs and significant demand uncertainty accounting for airports' pricing decision, airline competition and alternative airport objectives (profit maximization vs. welfare maximization). Analytical results from the model offer fresh insights on capacity investment at airports and have important policy implications.

(Picard et.al., 2019) studied the allocation of departing slots in airports with limited capacity. As slot management is the standard tool to manage airport capacity, it is important to investigate the impact of capacity constraints on one of the main factors underlying the use of time slots, namely the preference for peak time travel. Furthermore, (Nõmmik and Antov, 2017) studied the ascertainment of the regional airport specificities and possibilities for optimizing the capacity of regional airport terminals that provide services at a reasonable level. The results and findings of this research shall be implemented as the input for the regional airport terminal modelling. Also, possible measures for increasing regional airport terminal capacity were offered. Often airlines demand that the airport's ground handling close the check-in 35 or 40 minutes before any departure and minimizing of this time could reinforce the regional airport competitive advantages and create additional opportunities for capacity optimization.

(Amaruchkul and Lorchirachoonku, 2010), the major contribution of the study was to extend the allotment management to the case of multiple forwarders. The multiple-forwarder case is observed more frequently in practice compared to the single-forwarder case. In the paper, a mathematical model was

developed to evaluate the expected profit for a given allotment combination and formulating a dynamic programming problem to find optimal allotments for multiple forwarder. (Bilotkach and Polk, 2011) studied an overview of the issues that are relevant to evaluation of an airport's market power. Using the relevant economic concepts and showing how they relate to the specifics of airport business, a general practical framework, which can be used for the airport market power assessment exercises has been provided.

In unique research (Correia et. al., 2007) a method to collect passenger responses about the overall level-of-service (LOS) provided at the airport passenger terminal along with the most important overall measures for each interviewed passenger have been determined. Although this was a complex research, it succeeded in obtaining overall measures that have been used to derive quantitative relationships between physical measures and passenger responses. Further, (Vaze and Barnhart, 2012) have done the calculation of a lower bound on system-wide delays that can be achieved in the absence of competition while satisfying all passenger demand and maintaining a comparable LOS with the current revenue management practices of individual carriers. Aggregate integrated integer programming models of timetable development and fleet assignment were developed and solved using a heuristic-based approach.

In a report published by Government of India (MoCA, 2012), it was emphasized that with better planning and booking systems, airlines will be able to anticipate cargo submissions, and have a back-up plan in place so that no shipper / shipment suffers the consequences of offloading. Also, the capacity of the airlines to handle different types of cargo (Schafer, 2023), particularly the special handling / storage needs of Dangerous goods, Valuable cargo, Perishables, etc. has to be taken care of. The present rampant problems of short-shipments, missing / untraceable packages, mishandling / damage to packages, pilferages, etc. must be significantly eliminated with the cooperation of all the related agencies. Likewise, flight checking after flight arrivals, segregation of shipments and depositing with custodians / transfers for transshipments, etc. must be managed within benchmarked time frames and without error / delay. Further, steps should be taken to augment trained personnel and to introduce knowledge-based management, effectively integrated systems of warehouse management and inventory management. The report also focusses on the infrastructure gaps of cargo operations in India, when compared with global

best practices. The publication (ICAO, 2015), provides an introduction to how all the various elements including: aircraft operators, express carriers, postal operators, regulated agents, consignors, consignees, hauliers and ground handlers fit together. (Adenigbo et.al., 2019) assessed the capacity of infrastructure for cargo operations at cargo terminal and found that there exists an adequate infrastructure which are in good condition for cargo handling and determined the capacity and capacity constraints at terminal. (ACI-NA Air Cargo Committee Report, 2019) established a guide which is an ideal instrument to expand the knowledge base of interested air cargo professionals at airports and throughout the industry and it will benefit the airports, and in so doing enhance local and regional economies through growth in their supply chain and trade-related sectors. However, the air cargo industry constantly evolves and creates new issues and challenges for airports to confront.

2.2 Air cargo Demand Forecasting and Capacity expansion

(Eberlin, 1985) studied different statistical techniques in system dynamics and provided a practical guide that will allow modeler to gain some understanding of different approaches available. Further, (Barlas, 1996) focused on the formal aspects of validation and presented a taxonomy of various aspects and steps for formal model validation. Since structure-oriented behavior tests combine the strength of structural orientation with the advantage of being quantifiable, they seem to be the most promising direction for research on model validation. In addition to this, a case study done by (Lyneis, 1998) illustrate that by capturing the causes of industry dynamics, system dynamics models can provide better forecasts than traditional approaches. It also described, how the model was used to identify important structural changes in the industry, to avoid unnecessary capacity expansion, and to identify strategies to best "bridge" a business downturn. Also, the book (Sterman, 2000) provided thorough coverage of the field of system dynamics today, by examining systems thinking and the system dynamics worldview. The book discussed, Tools for systems thinking, including methods to elicit and map the structure of complex systems and relate those structures to their dynamics; Tools for modeling and simulation of complex systems; Procedures for testing and improving models; Guidelines for working with client teams and successful implementation. In addition to this, (Lyneis, 2000) stressed on these three points: (1) system dynamics models can provide more reliable forecasts of short- to mid-term trends than statistical models, and therefore lead to better decisions; (2) system dynamics models provide a means of understanding

the causes of industry behavior, and thereby allow early detection of changes in industry structure and the determination of factors to which forecast behavior are significantly sensitive; and (3) system dynamics models allow the determination of reasonable scenarios as inputs to decisions and policies. (Pruyt, 2011) illustrated the two model-based approaches for supporting policymaking for complex and uncertain issues as well as their combination. It has been found that policymakers / decision makers also need to feel the need to take uncertainty seriously into account in policymaking / decision making – they need to be convinced by the omnipresence of uncertainties and the importance of taking them into account. (Jiang et.al., 2003) described an analysis of future air cargo demand in China and its implications for system infrastructure. By extrapolating current trends and evaluating government policies, a forecast for future air cargo demand was made using econometric methods.

(Lin and Chen, 2003) analyzed the government documents and interviewed the air cargo carriers and airlines that served the Taiwan–China air cargo market so as to tabulate the trade, estimate the airport-to-airport air cargo demand and calibrate the international and domestic freight tariffs. (Houston, 2004) adopted a systematic analytical approach based on the economic principles of supply response functions to forecast the number of broilers in future years under the influence of changing economic variables. The study also reflected that there exists no substantive difference between using structural and time series models for broiler water forecasting purposes, indicated that an appropriate lag structure can fully capture the information used in structural models, assuming no structural change. Further, (Karlaftis, 2008) analyzed the general issue of forecasting highly seasonal demand in regional airports, where peak flows approach airport capacity. For this, dynamic Tobit models with GARCH errors / disturbances have been used and results showed that: a) Not explicitly accounting for seasonal variations in demand or for traffic approaching capacity may significantly bias model parameter estimates and affect demand predictions; and, b) Improved demand model specifications are an invaluable tool in obtaining more accurate demand estimates.

(Peng and Chu, 2009) provided the comparison of univariate methods for forecasting container throughput and provided a model for accurate prediction of container throughput by using six univariate models including the classical decomposition model, the trigonometric regression model, the regression model with seasonal dummy variables, the grey model, the hybrid grey model, and the SARIMA model.

(Suryani et.al., 2010) developed a model to forecast air passenger demand and evaluated some policy scenarios related with runway and passenger terminal capacity expansion to meet the future demand. In addition to this, (Suryani et.al., 2012) fulfills one of the objectives of the researcher as it established an approach to forecast air cargo demand related to terminal capacity expansion. System dynamics simulation model can provide reliable forecast and generate scenarios to test alternative assumptions and decision. One of the objectives of the (MoCA, 2012) report was to recommend policy initiatives to address important issues considering the long-term perspective and future growth potential in India. Also, a comparative analysis for cargo forecast using different techniques have also been discussed, but there exist gaps in the facility infrastructure at Cargo terminals in Gateway airports.

An in-depth case-study was done by (Magaña and Mansouri, 2016) to explore and untangle the factors influencing demand forecasting and consequently to improve the operational performance of an Air Cargo Handling Company. Further, a range of additional hidden factors that affect operations management have been identified and a number of recommendations have been made to improve demand forecasting and workforce management. (Boeing World Air Cargo Forecast Report, 2022) identified the key global economic indicators that impact air cargo, constituted a wide range of industry data sources, and employed a variety of analytical methods: econometric modeling, judgmental evaluation trend analysis techniques, and the Boeing Freighter Fleet Forecast. (Jacquillat and Odoni, 2017) synthesized the major interventions available to manage airport demand and capacity, the analytical tools that may support the underlying policy, managerial and operational decisions, and guidelines for policy and practice were obtained. Firstly, airport throughput exhibits significant variability, and airport capacity depends on the available infrastructure and operating procedures. Secondly, airport on-time performance is highly non-linear, and thus sensitive to variations in demand and capacity. Lastly, airport demand management involves a trade-off between mitigating congestion and maximizing capacity utilization, and scheduling mechanisms can support and enhance existing practices.

2.3 Global Trade

(Zhang and Zhang, 2002) provided a general discussion of various issues related to the liberalization of air cargo services in international aviation. It showed that all-cargo carriers may have different routing

needs than passenger carriers and thus require different sets of air traffic rights from those needed by passenger carriers. On the other hand, separation of air cargo and passenger rights will be fraught with difficulty in Asia because of distinctive characteristics of its air cargo market, where most passenger carriers have substantial cargo business and operate ‘‘combi’’ fleets. Customs and inter-modal transportation are also discussed in the context of cargo liberalization. The air cargo volume throughout of the world has strongly linked to trade growth and has grown at between 1.5 and 2 times the rate of worldwide GDP growth. In addition to this, (Bhonsale, 2023) also found in his paper that air connectivity boosts economic growth potential, thus enabling trade and investments, as aviation carries only 0.5 per cent of world trade by volume, but it represents 34.6 per cent of global trade by value.

(Ohasi et.al., 2004) applied an aggregate form of multinomial logit model to identify the critical factors influencing air cargo transshipment route choice decisions and analysis focuses on the trade-off between monetary cost and time cost while considering other variables relevant for choice of transshipment airport.

Porter (1990) in his book documented the correlation between air cargo and GDP growth. According to Porter and international business academicians, outward foreign direct investment (FDI) can generate a competitive strength to the nation’s industry. Foreign direct investment (FDI) is investment of foreign assets directly into a domestic company’s structures, equipment, and organizations. Also, a study conducted by (Gupta et. al., 2023) described that when it comes to foreign direct investment, three things matter a lot: the existence of ownership-specific competitive advantages (O), locational advantages (L), and superior commercial benefits (I) inside a company, all according to Dunning's OLI paradigm. (Kasarda and Green, 2005) found that there exists an empirical relationship between air cargo and trade and gross domestic product per capita, also three factors that can enhance air cargo’s positive impact: air service liberalization, improving customs quality, and reducing corruption. (Li and Liu, 2005) investigated that whether foreign direct investment (FDI) affects economic growth based on a panel of data for 84 countries over the period 1970-99. Both single equation and simultaneous equation system techniques were applied to examine this relationship and there exists a significant endogenous relationship between FDI and economic growth. (Love and Chandra, 2005) have done a systematic empirical investigation of the relationship of trade and growth and the findings suggested that the

direction of both long and short-term causality was from income to exports. All three i.e., GDP, trade and exports have co-integration. In addition to this, (Yao and Wei, 2006) found that FDI is a powerful driver of economic growth for a newly industrializing economy to catch up with the world's most advanced countries. Further, FDI and export have a relationship, which means that FDI can stimulate exports. (Senguttuvan, 2006) evaluated the impact of air cargo trend resulting from aviation sector relating to policies, development of airports and airlines in Asia and main emphasis was given on the performance of airports, airlines, regulatory agencies and logistic in order to facilitate to growing demand of air trade in the region. In nut shell air cargo, trade, and GDP have a direct relationship and are interdependent. (Hsiao and Hsiao, 2006) examined the Granger causality relationships between GDP, exports, and FDI among China, Korea, Taiwan, Hong Kong, Singapore, Malaysia, Philippines, and Thailand, the eight rapidly developing East and Southeast Asian economies. GDP and inward FDI lead to export. (Matsumoto, 2007) examined that international air passenger and cargo flows within and among Asia, Europe, and America, and the degree of air traffic density for major cities worldwide, using a basic gravity model composed of GDP, population, distance, and several dummy variables. It was found that the air traffic density in some cities such as Seoul, Hong Kong, and Amsterdam, is growing at the extraordinary rate.

(International Air Transport Association, 2021) in this report it has been observed that, air cargo has overperformed global goods trade, a common pattern usually seen at the beginning of economic upturns, when businesses turn to air freight to rapidly restock inventories to meet rising demand. In 2020, air cargo generated $128 billion, which, at 34%, represented approximately a third of airlines' overall revenues, an increase of 10-15% compared with precrisis times. Furthermore, (International Air Transport Association, 2022) report has analyzed that, in 2021 air cargo generated $155.0 billion, up from $129.0 billion in 2020 and $101.0 billion in 2019. Air cargo therefore contributed more than a third of airline revenues in 2021, over double its contribution in 2020. Global demand for air cargo was up 6.9% compared with the pre-covid level in 2019 and increased up18.7% compared with the level in 2020. Hence it can be said that, air cargo is the backbone of global supply chains. Also, (Boeing World Air Cargo Forecast Report, 2022) stated that air cargo accounts for less than 1% of the world's trade tonnage, the high value of these goods means it is responsible for about 35% of the value of all globally

shipped goods. This year's forecast summarizes the world's air trade markets, identifies major trends by region, and projects the performance and development of both global markets and the world's freighter fleet.

Further, (India Brand Equity Foundation, 2022) report has found that, India is the 7th largest civil aviation market in the world and is set to become the world's 3rd largest by 2024 as said by IATA. Further, the amount of cargo handled has increased from 703,000 (in the year 2000) to 3,328,296 (in the year 2021). As per Airports Authority of India (AAI) data, between FY16 and FY22, freight traffic increased at a CAGR of 2.52% from 2.70 MMT to 3.14 MMT. Freight traffic stood at 1,620,533 MT in FY 2022-23 (April-September 2022). Freight traffic on airports in India has the potential to reach 17 MMT by FY40. As a result, growth in import and export in India will be the key driver for growth in freight traffic as 30% of total trade is undertaken via airways.

SECTION 3: Objectives of the Study

In the light of studies done so far, the objectives of the proposed study are as follows:

1. **To study the existing operations management and capacity utilization of Air Cargo at IGIA, New Delhi.**

Here, the main focus will be to understand the existing cargo operations at both airport cargo terminals and how the capacity is utilized according to cargo tonnage availability.

2. **To identify the variables and issues affecting air cargo demand and capacity utilization.**

Here the aim will be to determine the important variables and issues that will affect the air cargo demand and capacity.

3. **To analyze the impact of global trade demand on capacity management.**

Here the capacity of IGIA in the handling of cargo traffic in terms of the adequacy and condition of warehouse, handling equipment, processing shed, and storage facilities will be assessed.

4. **To develop and recommend a decision making model for future air cargo demand and terminal capacity planning.**

Here the aim will be to develop a model to forecast future air cargo demand and terminal capacity planning as per global trade activities.

SECTION 4: Research Design and Methodology

4.1 Formulation of Research Hypotheses

Previous research done by (Senguttuvan & Senguttuvan Manager, n.d.-a) discussed that airport helps in providing facilities to aircraft, passenger and freights to meet the air travel demand by means of building up of an airport and air cargo terminal in the regions. The airport capacity has been affected by different operational, economic and environmental constraints. Capacity refers to the ability of an airport to handle a given volume or magnitude of traffic (demand) within a specific period of time. (Bilotkach & Polk, 2011) stated that airports which are capacity constrained in one or the other way will have difficulty accommodating new airlines or expanded services by the incumbent carriers. (A.J. Adenigbo,2019) said that focus of airport management is to ensure adequacy of capacity to handle the anticipated demand of traffic in efficient way and the amount of cargo that are processed has no delay. (Suryani et.al., 2012) have found that, acquiring the right amount of air cargo terminal space has often been a major challenge for the airport authority due to high demand uncertainties. Hence, there are casual linkages among air cargo operations, capacity utilization and air cargo demand.

Following hypotheses are proposed for this study :-

H1: There is significant positive linkage between air cargo operations and terminal capacity utilization

As per ICAO Report 2015, cargo supply chains are the process of moving consignments from origin to destination, are often complex and subject to a range of regulatory requirements, especially when they include international movements and transport by air. The cargo will be handled along the chain by a number of entities with varying responsibilities, including aircraft operators, express carriers, postal operators, regulated agents, consignors, consignees, haulers and ground handlers. (A.J. Adenigbo,2019) said that focus of airport management is to ensure adequacy of capacity to handle the anticipated traffic in efficient way. The overall capacity is determined by the quantity and condition of airport infrastructure such that cargos are processed without delay and at reduced cost. The study done by (Nommik and Antov,2017), modelled airport terminal capacity to avoid overdesign of infrastructure for cargo handling services. Hence, there exists positive linkages between air cargo operations and capacity utilization.

H2: There is significant positive linkage between capacity utilization and air cargo demand

Matthew G. Karlaftis (2008), made a forecast to determine highly seasonal demand in regional airports, where peak flows approach airport capacity. (Suryani et. al.,2010), developed a model to forecast air passenger demand and passenger terminal capacity expansion. Also, (Suryani et. al.,2012), analyzed the relationship between terminal capacity planning and air cargo demand. (Uriel Magaña Olmos, 2016) explored the factors influencing demand forecasting consequently to improve the operational performance of an Air Cargo Handling Company. Alexandre Jacquillat (2017), found the interventions available to manage airport demand and capacity. Hence, there exists significant linkages between capacity utilization and air cargo demand.

H3: There is significant positive linkage between global trade and air cargo demand

(Porter,1990) augmented the relationship that outward Foreign Direct Investment (FDI) can generate a competitive strength to the nation's industry. Xiaoying and Xiaming (2005) analyzed that there is an endogenous relationship between foreign direct investment and economic growth. Love and Chandra (2005), stated that GDP and foreign direct investment (FDI) have direct relationship to export. Jiang et al. (2003) has found that there is a relationship between GDP and air cargo demand. In addition to this, Zhang and Zhang (2002) analyzed that the air cargo volume throughput of the world has strongly linked to trade growth and has grown at between 1.5 and 2 times the rate of worldwide GDP growth. Hence, there exists positive linkages between global trade and air cargo demand.

4.2 Pilot study

The researcher conducted in-depth interview with 6 concerned administrative officials i.e., 2 Senior Managers, 2 Managers at CDCTMIPL and 1 Manager, 1 Shift Duty Manager at DCSC to explore all the relevant dimensions and variables with reference to the research problem proposed in this study. The interview consisted of open-ended questions primarily focusing on operations of air cargo, warehouse infrastructure, handling equipments, storage facilities, challenges faced and number of employees available at both the terminals. Their observations and inputs were crucial for the researcher to frame the research objectives and hypothesis.

4.3 Sample Composition

Number of Cargo terminals in Delhi – 02

There are two cargo terminals in Delhi operated by Celebi Delhi Cargo Terminal Management India

Pvt. Ltd. (CDCTMIPL) and Delhi Cargo Service Centre (DCSC).

Number of Cargo terminals in Mumbai – 02

There are two cargo terminals in Mumbai operated by Sahar Air cargo complex and Mumbai International Air Transport Limited (MIAL).

Respondents

The respondents will be the officials of CDCTMIPL, DCSC, Sahar Air cargo complex and MIAL dealing with cargo operations mainly comprising of :

Table 3: Officials of CDCTMIPL, DCSC,MIAL,Sahar Cargo complex

Name of Cargo terminals							
DCSC		CDCTMIPL		MIAL		Sahar cargo complex	
Designation	No.of employees	Designation	No.of employees	Designation	No.of employees	Designation	No.of employees
Deputy General Manager	1	Chief Operating Officer	1	Deputy General Manager	1	Deputy General Manager	1
Manager	4	Senior Manager	2	Manager	4	Manager	4
Duty Manager	4	Manager	2	Shift Duty Manager	15	Shift Duty Manager	8
Duty Manager Trainee	1	Shift Duty Manager	10	Senior Duty Officer	70	Senior Duty Officer	10
Assistant Manager	12	Senior Duty Officer	80	Duty Officer	110	Duty Officer	30
AS	1	Duty Officer	100	Senior Cargo officer	40	Senior Cargo officer	11
Senior Cargo officer	32	Cargo Officer	200	Cargo Officer	210	Cargo Officer	50
Cargo officer	57						
Total	112	Total	395	Total	450	Total	114
Total Population (N)				112+395+450+114 = 1071			
After applying Cochran's Formula sample size (n) = 392(approx)							

(Source: CDCTMIPL,DCSC,MIAL,Sahar Cargo complex 2023)

4.4 Sampling Technique: Judgemental Purposive Sampling

Judgemental Purposive Sampling is a strategy in which particular settings, persons or events are selected deliberately in order to provide important information that cannot be obtained from other choices

(Maxwell, 1996). It is where the researcher includes cases or participants in the sample because they believe that they warrant inclusion.

Sources of Data:

The researcher seeks to gather both qualitative and quantitative data. Researcher seeks to focus on primary data to analyze the present condition of Delhi Cargo Terminals. Validity and reliability of the questionnaire will be established on the basis of previous researches and pilot survey. The researcher will also make use of the secondary sources of data collection in the form of gathering published materials such as extracts from relevant Journals, Reports, Books and Periodicals covering the present study.

4.5 Modelling and Simulation Tools for Data-Analysis

a) System Dynamics/ Causal Modeling

System dynamics is a powerful methodology to understand and discuss the behavior and structure of complex problems over a time. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems-literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality.The simulation tools used for analysis will be Stella and Vensim.

b) Correlation Analysis

Correlation analysis analyses the joint variation of two or more variables for determining the quantum of correlation between two or more variables.

c) T- Test

T-test is based on t-distribution and is considered an appropriate test for judging the significance of a sample mean or for judging the significance of difference between the means of two samples in case of small sample (s) when population variance is not known (in which case is use variance of the sample as an estimate of the population variance).

d) Chi- Square test

The Chi-square(χ^2) test is applicable in large number of problems. The test is, in fact, a technique through the use of which it is possible for all researchers to: (i) test the goodness of fit; (ii) test the significance of association between two attributes, and (iii) test the homogeneity or the significance of

population variance.

e) Scaling Technique: Likert Scale

The respondents will be asked to respond to each of the statements in terms of several degrees, usually five degrees of agreement or disagreement but here 3-point likert scale will be used so as to capture only positive responses as negative responses related to air cargo terminal infrastructure will not exist for cargo handling in practical situation.

4.6 Methodology

Table 4: Methodology

Research Strategy	A mixed method of qualitative and quantitative
Survey Method	Questionnaire, Face-to-Face and Telephonic interviews
Nature of Study	Descriptive and Analytical
Population	Experts at IGIA dealing with cargo terminal operations
Type of Population	Finite
Sampling frame (Unique address of every respondent in population)	Experts Id
Sampling Unit (on whose behalf response is taken)	As an expert in air cargo area
Sampling Method	Judgemental Purposive Sampling
Modelling and Simulation Tools	Stella and Vensim
Parameters to determine sample size	
Primary variable of interest	Continuous (metric)
Error estimation a) Alpha level b) Acceptable margin of error (e) c) Formula to calculate sample size	5% always (Ary, Jacobs, & Razavieh, 1996) 3% for Continuous data (Krejcie & Morgan, 1970) n = (z * sigma / e) ^2 * N at alpha level 5%; z= 1.96; e= .03
Variance estimation	Estimate the structure of the population assisted by some logical mathematical results. Range = 6 *sigma
Steps for sample size determination	
Step-1: Calculate Sample size by Cochran's Formula	Sample size = $\frac{(z^* \text{ Sigma})^2 * N}{(N-1) * e^2 + (z^2 * \text{Sigma}^2)}$ where z=1.96 (For alpha=5% in social science studies) e= 0.03 for Continuous data Sigma = 0.5 (for 3-point scale) So, for a Finite population where 3-point scale is used for data collection (N=1071) n = (1.96 * 0.5) ^ 2 *1071

	(1071-1) *(0.03) ^2 + (1.96 * 0.5) ^2 = 535 approximately (This sample exceeds 5%of population)
Step-2: Finite Population Correction (Cochran's formula)	Sample size by step 1 New = (1 + Sample size by Step-1 / Population) Sample = 356.7 (approx.)
Step-3: Over-Sampling	Sampling non-respondents: Donald (1967), Hagbert (1968), Johnson (1959), and Miller and Smith (1983) recommend that the researcher take a random sample of 10-20% of non-respondents to use in non-respondent follow-up analyses Result of 10% of step 2 + step 2 result = 392 (approx.)

(Source: Author's own compilation)

4.7 Plan of Work

The Proposed plan of work as will be conducted, is shown in the following stacked bar chart:

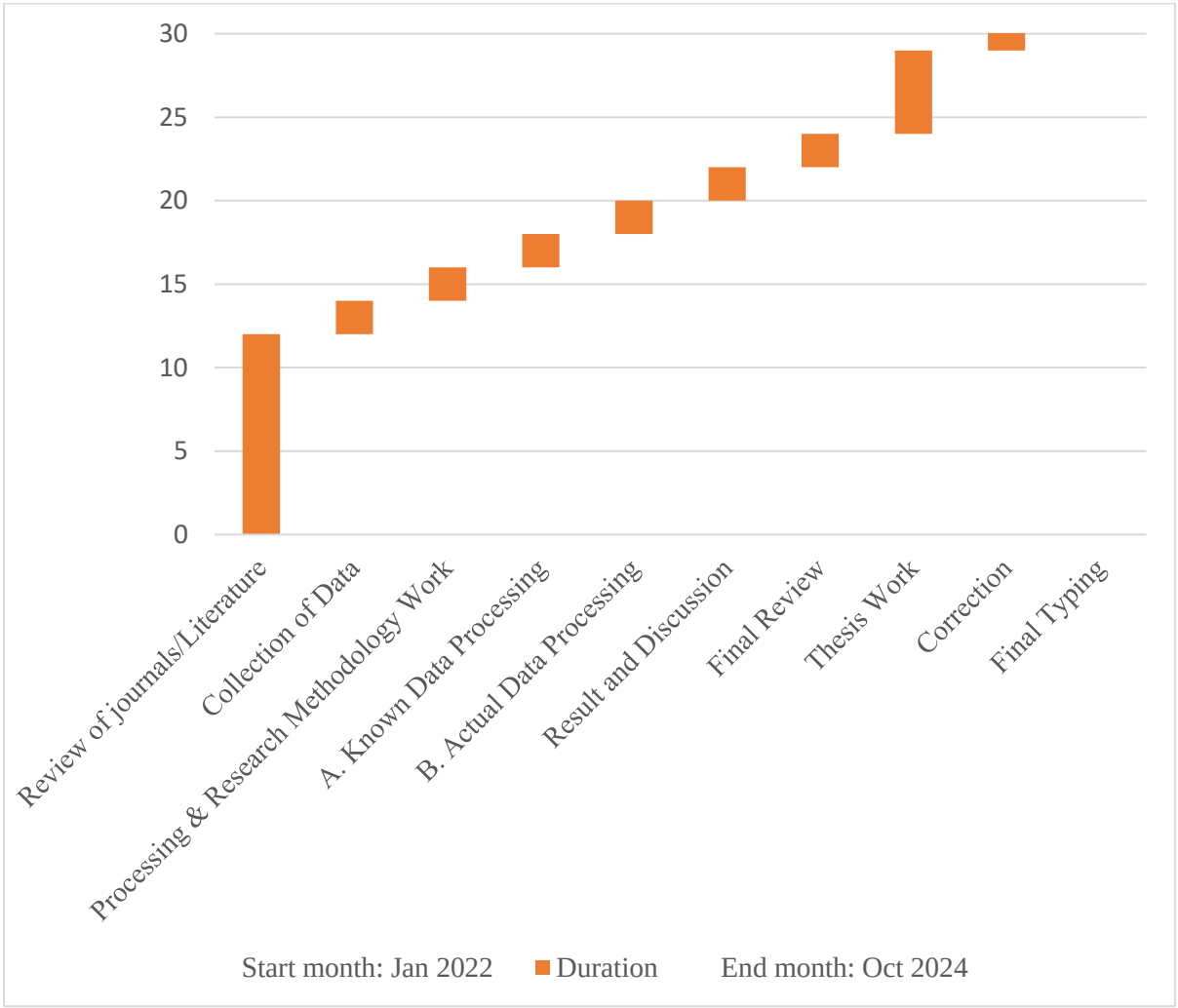

Figure 3: Plan of Work

SECTION 5: Proposed Chapterization of Thesis

Chapter 1: Introduction

Chapter 2: Review of Literature

Chapter 3: Research Design and Methodology

Chapter 4: Analysis and Results

Chapter 5: Conclusions

Appendix

References

References

- Adenigbo, A. J., Okoko, E. E., & Gbadamosi, K. T. (2019). Assessment of Terminal Capacity for Cargo Handling in Lagos Airport, Nigeria. *Global Journals of Research in Engineering*, *19*(E2), 1-8.
- Airports_Council_International_Report_2019.
- Amaruchkul, K., & Lorchirachoonkul, V. (2011). Air-cargo capacity allocation for multiple freight forwarders. Transportation Research Part E: Logistics and Transportation Review, 47(1), 30–40. https://doi.org/10.1016/j.tre.2010.07.008
- Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. System Dynamics Review: The Journal of the System Dynamics Society, 12(3), 183-210.
- Bhonsale, M. S. (2023). Enhancing Multimodal Connectivity in the BBIN Sub-region. https://cuts-citee.org/pdf/dp-mconnect-in-the-bbin-sub-region-air-connectivity-in-perspective.pdf.
- Boeing_World_Air_Cargo_Forecast_2022.
- Correia, A. R., Wirasinghe, S. C., & Barros, A. G. de (2008). Overall level of service measures for airport passenger terminals. Transportation Research Part a: Policy and Practice, 42(2), 330–346. https://doi.org/10.1016/j.tra.2007.10.009
- Eberlein, R. L., & Wang, Q. (1985). Statistical estimation and system dynamics models. In Proceedings of the International System Dynamics Conference (Vol. 206).
- Ghosh, S. (2022). Synergizing Air Cargo Operations Efficiency through Effective Implementation of Logistical Processes. https://jtaviation.in/images/journal/IJIRT154267_PAPER.pdf
- Gelhausen, M. C. (2011). Modelling the effects of capacity constraints on air travellers' airport choice.

Journal of Air Transport Management, 17(2), 116–119. https://doi.org/10.1016/j.jairtraman.2010.11.004

- Graham, A. (2023). *Managing airports: An international perspective*. Taylor & Francis.
- Houston, J. E., Adhikari, M., & Paudel, L. (2004). Forecasting Broiler Water Demand: Econometric and Time Series Analysis (No. 1845-2016-152486).
- Hsiao, F. S., & Hsiao, M.-C. W. (2006). FDI, exports, and GDP in East and Southeast Asia—Panel data versus time-series causality analyses. Journal of Asian Economics, 17(6), 1082–1106. https://doi.org/10.1016/j.asieco.2006.09.011.
- ICAO_WCO_Moving_Air_Cargo_en_2015
- India_Brand_Equity_Foundation_2022.
- International_Air_Transport_Report_2021.
- International_Air_Transport_Report_2022.
- Jacquillat, A., & Odoni, A. R. (2018). A roadmap toward airport demand and capacity management. Transportation Research Part a: Policy and Practice, 114, 168–185. https://doi.org/10.1016/j.tra.2017.09.027
- Jiang, H., Ren, L., & Hansman, R. (2003, November). Market and infrastructure analysis of future air cargo demand in China. In AIAA's 3rd Annual Aviation Technology, Integration, and Operations (ATIO) Forum (p. 6770).
- Karlaftis, M. G. (2008). Demand forecasting in regional airports: dynamic Tobit models with GARCH errors. Sitraer, 7, 100-111.
- Kasarda, J. D., & Green, J. D. (2005). Air cargo as an economic development engine: A note on opportunities and constraints. Journal of Air Transport Management, 11(6), 459–462. https://doi.org/10.1016/j.jairtraman.2005.06.002
- Kotrlik, J. W. K. J. W., & Higgins, C. C. H. C. C. (2001). Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research. *Information technology, learning, and performance journal*, *19*(1), 43.
- Lin, C.-C., & Chen, Y.-C. (2003). The integration of Taiwanese and Chinese air networks for direct

air cargo services. Transportation Research Part a: Policy and Practice, 37(7), 629–647. https://doi.org/10.1016/S0965-8564(03)00010-7

- Li, X., & Liu, X. (2005). Foreign direct investment and economic growth: an increasingly endogenous relationship. World development, 33(3), 393-407.
- Love, J., & Chandra, R. (2005). Testing export-led growth in Bangladesh in a multivarate VAR framework. Journal of Asian Economics, 15(6), 1155–1168. https://doi.org/10.1016/j.asieco.2004.11.009
- Lyneis, & M, J. System Dynamics In Business Forecasting: A Case Study of the Commercial Jet Aircraft Industry.
- Lyneis, J. M. (2000). System dynamics for market forecasting and structural analysis. System Dynamics Review: The Journal of the System Dynamics Society, 16(1), 3-25
- Magaña, U., Mansouri, S. A., & Spiegler, V. L. (2017). Improving demand forecasting in the air cargo handling industry: a case study. International Journal of Logistics Research and Applications, 20(4), 359-380.
- Mahmood, Z. (1998). Michael E. Porter. The Competitive Advantage of Nations. New York: Free Press, 1990. 855 pages. Hardbound. UK£ 25. The Pakistan Development Review, 90-94.
- Matsumoto, H. (2007). International air network structures and air traffic density of world cities. Transportation Research Part E: Logistics and Transportation Review, 43(3), 269–282. https://doi.org/10.1016/j.tre.2006.10.007
- Ministry_of_Civil_Aviation_Report_2012
- Nõmmik, A., & Antov, D. (2017). Modelling Regional Airport Terminal Capacity. Procedia Engineering, 178, 427–434. https://doi.org/10.1016/j.proeng.2017.01.083
- Ohashi, H., Kim, T. S., Oum, T. H., & Yu, C. (2005). Choice of air cargo transshipment airport: an application to air cargo traffic to/from Northeast Asia. Journal of Air Transport Management, 11(3), 149-159.
- Peng, W.-Y., & Chu, C.-W. (2009). A comparison of univariate methods for forecasting container throughput volumes. Mathematical and Computer Modelling, 50(7-8), 1045–1057.

https://doi.org/10.1016/j.mcm.2009.05.027

- Picard, P. M., Tampieri, A., & Wan, X. (2019). Airport capacity and inefficiency in slot allocation. International Journal of Industrial Organization, 62, 330–357 https://doi.org/10.1016/j.ijindorg.2017.10.003
- Polk, A., & Bilotkach, V. (2012). The assessment of market power of airports. Available at SSRN 2016126.
- Pruyt, E. (2011). Heart meets mind: Smart transition management to smarten energy systems in a deeply uncertain world. In Proceedings of the 29th International Conference of the System Dynamics Society, Washington, USA, 25-29 July 2011. System Dynamics Society.
- Sahoo, R., Bhowmick, B., & Tiwari, M. K. (2023). Developing a model to optimize the cost of consolidated air freight considering the varying scenarios. *International Journal of Logistics Research and Applications*, *26*(8), 1035-1059.
- Schafer, J.G. (2022). Air Cargo: Participants-Process-Markets-Developments. Springer. https://doi.org/10.1007/978-3-658-38193-6_6.
- Senguttuvan, P. S. (2006, February). Air Cargo: Engine for economic growth and development–a case study of Asian region. In National Urban Freight Conference (pp. 1-3).
- Senguttuvan, P. S. (2006, March). Economics of the airport capacity system in the growing demand of air traffic–a global view. In 47th Annual Transportation Research Forum, New York, New York, March 23-25, 2006 (No. 208018). Transportation Research Forum.
- Sterman, J. (2000). Business dynamics: Systems thinking and modelling for a complex world. Irwin/McGraw-Hill.
- Suryani, E., Chou, S.-Y., & Chen, C.-H. (2010). Air passenger demand forecasting and passenger terminal capacity expansion: A system dynamics framework. Expert Systems with Applications, 37(3), 2324–2339. https://doi.org/10.1016/j.eswa.2009.07.041
- Suryani, E., Chou, S.-Y., & Chen, C.-H. (2012). Dynamic simulation model of air cargo demand forecast and terminal capacity planning. Simulation Modelling Practice and Theory, 28, 27–41. https://doi.org/10.1016/j.simpat.2012.05.012

- Xiao, Y., Fu, X., & Zhang, A. (2016). Airport capacity choice under airport-airline vertical arrangements. *Transportation Research Part A: Policy and Practice*, *92*, 298-309.
- Xiao, Y. B., Fu, X., Oum, T. H., & Yan, J. (2017). Modeling airport capacity choice with real options. Transportation research part B: methodological, 100, 93-114.
- Vaze, V., & Barnhart, C. (2012). An assessment of the impact of demand management strategies for efficient allocation of airport capacity. *International Journal of Revenue Management*, *6*(1-2), 5-27.
- Yao, S., & Wei, K. (2007). Economic growth in the presence of FDI: The perspective of newly industrialising economies. Journal of Comparative Economics, 35(1), 211-234
- Zhang, A., & Zhang, Y. (2002). Issues on liberalization of air cargo services in international aviation. Journal of Air Transport Management, 8(5), 275-287.

Websites

- https://cargo.newdelhiairport.in/
- https://www.aai.aero/en/business-opportunities/aai-traffic-news
- https://www.acmes.in/Live/index.aspx
- http://cargotalk.in/
- https://www.celebiaviation.com/india
- https://www.aai.aero/en/business-opportunities/aai-traffic-news
- https://www.aai.aero/en/cargo/mumbai_overview.jsp